PROC. ENTOMOL. SOC. WASH.
87(4), 1985, pp. 834–842

A COMPARISON OF GROUND BEETLE (COLEOPTERA: CARABIDAE) FAUNAS OF VALCOUR ISLAND IN LAKE CHAMPLAIN, NEW YORK AND THE ADJACENT MAINLAND

JANINE E. POWELL[1] AND J. STALLARD WATERHOUSE

Department of Biological Sciences, SUNY College of Arts and Science, Plattsburgh, New York 12901.

Abstract.—Fifty-three ground beetle (Coleoptera: Carabidae) species were obtained in this study, with 21 species common to both Valcour Island in Lake Champlain, New York and the adjacent mainland area 1.6 km distant. Twenty-seven species were found only on the mainland whereas five species were found only on the island, including the short-winged *Carabus nemoralis* Muller. *Carabus maeander* Fischer was normal-winged on the island, but short-winged on the mainland. Nearly nineteen percent more normal-winged specimens of the dimorphic *Pterostichus melanarius* Illiger occurred on the island than on the mainland.

Although the vegetation, birds, and mammals of Valcour Island in Lake Champlain have been studied to varying extents (Crissey and Darrow, 1949; Klein, 1972), the island's insect fauna has not been catalogued. Leonard (1928) listed the insects of New York, but localities for ground beetles (Coleoptera: Carabidae) did not include Valcour Island. Lindroth's (1961, 1963a, 1966, 1968, 1969a, b) work on the ground beetles of Canada and Alaska covered New York, as well.

Variability in carabid dispersal sometimes can be attributed to wing polymorphism (Darlington, 1936, 1943). For example, the wings of many species are always rudimentary, consequently, their activities are restricted to the soil and their distribution range is narrow. Other species possess long wings and, provided wing musculature has not atrophied, are capable of flight. Finally, in the case of wing dimorphic species, both normal- and short-winged individuals occur. Wing state is strongly correlated with locality and habitat (Darlington, 1943); arboreal and hydrophilous species are nearly always normal-winged, whereas geophilous species are usually dimorphic or short-winged.

Faunal studies are important for local records on insect diversity and population structure as well as taxonomically for evolutionary and faunal histories between countries and continents, such as those reported by Lindroth (1957, 1963b, 1971). This study was undertaken to categorize ground beetle species collected in various ecological habitats of an island and adjacent mainland area, and to compare faunas of the two areas.

[1] Present address: USDA, ARS, P.O. Box 225, Stoneville, MS 38776.

Materials and Methods

Ground beetles were collected from 26 May through 24 October 1976 on Valcour Island and the adjacent mainland. Six different types of collecting sites on Valcour Island were identified on the basis of habitat differences. Mainland sites were selected which corresponded to the different island sites with respect to vegetation, soil, and drainage. These sites were named and abbreviated accordingly: mainland shore (M-SH); island shore (I-SH); mainland open field (M-OF); island open field (I-OF); mainland semi-open field (M-SF); island semi-open field (I-SF); mainland swamp (M-SW); island swamp (I-SW); mainland deciduous woods (M-DW); island deciduous woods (I-DW); mainland cedar woods (M-CW); and island cedar woods (I-CW). A description of each mainland and island site is given in Table 1. The flora was identified, and relative abundance was noted.

Descriptions of collecting sites.—Both the mainland and island study areas were approximately 10 km south of the city of Plattsburgh in Clinton County, New York. Valcour Island is located in Lake Champlain along a north-south axis approximately 1.6 km from the New York mainland. Crissey and Darrow (1949) described the island as having: a length of 3200 m and a width of 1600 m, with an area of 425 ha; an irregular shoreline about 16,000 m long; a gently rolling topography with elevations varying from 31 to 55 m above the lake; shores mostly sloping to rock shingle or sand beach, although the southern shore rises 24 m in sheer cliffs; thin topsoil overlying creviced limestone; and good drainage, with only three vernal swamps of which only one is greater than 2 ha.

The topography of the mainland area, like that of the island, was gently rolling with altitudes of 31–61 m. Drainage appeared to be good, in general. This rural countryside was characterized by open fields, old field successional habitats, and sparse woods.

Collection of ground beetles.—Ground beetles were collected with pitfall traps within a 15.2 × 15.2 m area at most sites. Pitfall traps consisted of 0.95 liter glass jars buried upright with the opening flush with the ground surface. One trap was placed in the center of the plot, and six were placed each 3.0 m from the center in a hexagonal arrangement around the center trap at each OF, SF, and DW site. Seven pitfall traps were buried in random locations at the SW and CW sites. Pitfall traps were checked approximately every tenth day for island sites and every fifth day for mainland sites. Specimens were collected by hand at shore sites.

Sweep net samples were taken infrequently at OF, SF, and DW sites; and a soil sample (30.5 × 30.5 × 15.2 cm) was taken at each site. In addition, an ultraviolet (UV) light trap was operated at all mainland sites, and on the island at I-SH, I-OF, I-SF, and I-SW.

All specimens were identified using Barlow et al. (1969), Lindroth (1961, 1963a, 1966, 1968, 1969a, b), Perrault (1973), and Goulet (1974), and the wing state was examined. Species with rudimentary wings will be referred to as "short-winged," while those which possess long wings will be referred to as "normal-winged."

Results and Discussion

Mainland collections (714 specimens) yielded 48 species in 19 genera, 21 of which also occurred on Valcour Island (Table 2). Island collections (678 specimens) yielded 26 species in 11 genera, including five species found only on the

Table 1 Characteristics of mainland and island collecting sites (I = island, M = mainland, SH = shore, OF = open field, SF = semi-open field, SW = swamp, DW = deciduous woods, CW = cedar woods).

Site	Soil and Drainage	Dominant Vegetation
I-SH	Gravelly, stony beach	Ground cover: *Spartina pectinata* Link.
M-SH	Gravelly, stony boat launching site, large stones and rock piles	No vegetation
I-OF	Clay-loam, well-drained	Ground cover: *Dactylis glomerata* L.
M-OF	Clay, poor drainage	Ground cover: *D. glomerata*
I-SF	Clay-loam, moderate drainage	Ground cover: *D. glomerata, Melilotus alba* Desr., *Solidago* spp., *Aster novae-angliae* L.; Shrub layer: *Cornus stolonifera* Michx.
M-SF	Clay-loam, moderate drainage	Ground cover: *D. glomerata, Solidago* spp., *Aster* spp.; Shrub layer: *C. stolonifera, C. racemosa* Lam.
I-SW	Dark, porous soil, poor drainage	Ground cover: *Osmunda cinnamomea* L., mosses, numerous wildflowers; Understory: *Prunus* sp., *C. racemosa*; Canopy: young mixed forest—*Abies balsamea* (L.) Mill., *Thuja occidentalis* L., *Populus tremuloides* Michx., *Ulmus rubra* Muhl
M-SW	Poor drainage	Ground cover: *O. cinnamomea, Onoclea sensibilis* L., *Dryopteris noveboracensis* (L.) Gray, mosses; Understory: *Hamamelis virginiana* L., *Pyrus coronaria* L., *C. stolonifera*; Canopy: young mixed forest—*Tsuga canadensis* (L.) Carr., *Pinus strobus* L., *T. occidentalis, P. tremuloides, Ostrya virginiana* (Mill.) K. Koch, *Betula* spp., *Fagus grandifolia* Ehrh., *Quercus bicolor* Willd., *U. rubra, Acer* spp., *Tilia americana* L.
I-DW	Loam, good drainage	Ground cover: *D. glomerata, Avena fatua* L., numerous wildflowers; Shrub layer: *Rhamnus cathartica* L.; Canopy: *O. virginiana, Acer saccharum* Marsh.
M-DW	Loam, good drainage	Ground cover: *D. glomerata, Rhus radicans* L.; Shrub layer: *Juniperus virginiana* L., *Amelanchier laevis* Wieg; *R. cathartica, C. stolonifera*; Canopy: *P. tremuloides, F. americana*
I-CW	Sandy-loam, dry	Shrub layer: *Rhus typhina* L., *Cornus rugosa* Lam.; Canopy: *A. balsamea, T. occidentalis*; also, *T. canadensis*
M-CW	Sandy-loam, dry	Shrub layer: *Juniperus communis* L., *J. virginiana, R. cathartica*; Canopy: *T. occidentalis*; also, *P. strobus*

island (Table 2). These numbers are likely to change as the vegetation goes through successional stages or becomes changed by man.

A study of the ground beetles collected on Plummers Island, Maryland between 1901–1978 has shown how a carabid fauna can change over time (Erwin, 1981). According to Erwin (1981), the decrease in number of carabid species from 160

to 101 occurred as the island's flora changed from juniper-grassland to oak-hickory-maple. The carabid species composition changed from open-habitat species to forest dwellers, from wingless to winged species, and from species with large individuals to species with smaller individuals. Ecological and evolutionary considerations are discussed by Erwin (1981).

Pitfall catches accounted for the greater proportion of specimens collected, except SH sites where ground beetles were hand-collected, and M-OF and M-SF where most of the specimens were attracted to a blacklight. Soil sampling was ineffective in this study, contrary to Briggs' (1960) findings; only one beetle was found using this technique. None were attracted to the UV light when it operated at island sites, possibly because the temperature was too low on those particular nights.

The majority of the ground beetles collected had their expected wing structure (Table 2). However, a few species warrant additional discussion because of wing structure or distribution. The rare presence of a single normal-winged *Carabus maeander* (I-SF) may indicate a range extension southward from Canada. The appearance of this species in both major areas may indicate dispersal by normal-winged morphs. See Larochelle (1973) for a discussion of wing dimorphism in *C. maeander*. *C. maeander* was first reported in New York in 1977 (Powell, 1977).

Special attention is warranted for *C. nemoralis* in this discussion since it was present only at island sites. Yet, it is a short-winged species. Lindroth (1961) reported that this species, first found in North America 115 years ago, was restricted to cultivated ground. According to Barlow (1973), *C. nemoralis* has only recently been collected in forests. In this study, 87.9% of the *C. nemoralis* collected on Valcour Island were found in a deciduous woods. Mainland-based supplies, equipment, and animals were transported to the island when farming took place on the island at the turn of the century. This may explain the spread of this short-winged species on the island.

The dimorphic *Clivina fossor* apparently is new to the state; a single normal-winged specimen was collected in this study. This European introduction was first found in eastern Canada 70 years ago (Lindroth, 1961). The occurrence of normal-winged *Patrobus longicornis* is rare (Lindroth, 1961). Thus, collection of 13.3% in island sites was interesting because it may indicate dispersal by normal-winged morphs.

Although *Nebria lacustris*, *Pterostichus lucublandus*, *Agonum gratiosum*, *A. mannerheimi* and *A. decentis* had full wings, they probably were non-functional (Lindroth, 1961, 1966). *P. melanarius* is reported to occupy a wide variety of habitats ranging from open cultivated or non-cultivated areas to deciduous or coniferous forests. According to Lindroth (1966), the normal-winged form is rare in Europe, but not in North America. This is a sign that the species arrived late and is spreading. Of those specimens collected on the island, 56.5% were normal-winged, whereas only 37.9% of the mainland specimens were. *P. coracinus* was reported to be found both in the forest and in open fields and meadows (Lindroth, 1966). Barlow (1970) showed that for *P. melanarius* and *P. coracinus* populations, the greatest number of each species was found where the other was scarce or absent. This negative association may be the result of competition between the species or responses to different environmental requisites. This differential dis-

Table 2. Species, wing state, and abundance of ground beetles collected at island and mainland sites.[1,2]

Taxon (Wing State)	SH		OF		SF		SW		DW		CW		Total No.[3]
	I	M	I	M	I	M	I	M	I	M	I	M	
Cychrini													
Sphaeroderus lecontei Dejean (S)								R			R		3
Carabini													
Carabus maeander Fischer (D)					R	R							3
C. nemoralis Muller (S)[4]			R		C				A		R		190
Nebriini													
Nebria lacustris Casey (D)[5]		R											1
Elaphrini													
Elaphrus clairvillei Kirby (N)[5]								R					1
Scaritini													
Dyschirius integer Leconte (N)[5]				R						R			2
Clivina fossor Linne (D)[5]						R							1
Patrobini													
Patrobus longicornis Say (D)	R				R		C	R		R			19
Bembidiini													
Bembidion chalceum Dejean (N)[5]		R											2
B. planum Haldeman (N)[4]	R												1
B. salebratum Leconte (N)	C	C											38
B. scopulinum Kirby (D)[5]		C											12
B. castor Lindroth (N)[5]		R											1
B. patruele Dejean (N)[5]		R		R		R		R		R			6
B. versicolor Leconte (N)[5]						R							2
B. frontale Leconte (N)[5]										R			9
Tachys tripunctatus Say (N)	R	R											6

Table 2. Continued.

Taxon (Wing State)	SH		OF		SF		SW		DW		CW		Total No.[3]
	I	M	I	M	I	M	I	M	I	M	I	M	
Pterostichini													
Pterostichus tristis Dejean (S)								R			R		6
P. lucublandus Say (N)	R		R	R	R	R				C			64
P. adstrictus Eschscholtz (N)							R		R		R	R	21
P. melanarius Illiger (D)		R	A	R	C		R	R	C	A	R	R	570
P. coracinus Newman (S)					R		R	C	C		C	C	154
P. corvinus Dejean (N)[5]								R					2
P. caudicalis Say (N)[5]								R					9
P. luctuosus Dejean (N)	R						R	R		R			16
P. leconteianus Lutshnik (N)[4]					R								1
P. femoralis Kirby (D)[4]									R				1
Synuchus impunctatus Say (D)							R	R		R	C		29
Agonum gratiosum Mannerheim (N)							R	R					4
A. thoreyi Dejean (N)							R			R			2
A. lutulentum Leconte (N)[5]				R									1
A. anchomenoides Randall (N)[5]				R									2
A. melanarium Dejean (N)							R	C		C			54
A. trigeminum Lindroth (N)						R	R			R			9
A. harrisi Leconte (N)[5]				R									1
A. tenue Leconte (N)[5]				R									1
A. extensicolle Say (D)	C	C									R		49
A. mannerheimi Dejean (N)[5]								R					1
A. decentis Say (N)							R	R					4
A. tenuicolle Leconte (N)[5]		R											2
Harpalini													
Harpalus erythropus Dejean (N)[5]						R							1
H. fallax Leconte (N)[5]				R									3
Stenolophus ochropezus Say (N)[5]				R		R							2
S. comma Fabricius (N)	R			R									10
Acupalpus pumilus Lindroth (N)[5]						R							1
A. pauperculus Dejean (N)[5]				R									3

Table 2. Continued.

Taxon (Wing State)	SH		OF		SF		SW		DW		CW		Total No.[3]
	I	M	I	M	I	M	I	M	I	M	I	M	
Licini													
Diplocheila assimilis Leconte (N)[5]								R					2
Badister neopulchellus Lindroth (N)[5]				R									2
Chlaeniini													
Chlaenius cordicollis Kirby (N)	C	C											33
C. sericeus Forster (N)	R	R											2
C. impunctifrons Say (N)[5]								C		R			26
Lebiini													
Lebia viridis Say (N)[5]				R		R				R			6
Brachinini													
Brachinus cordicollis Dejean (N)[4]	R												1

[1] Abundance of carabids is expressed using a logarithmic scale: R = rare, 1–10 specimens; C = common, 11–100 specimens; and A = abundant, >100 specimens.
[2] The letters following species names refer to the wing states (Lindroth, 1961, 1963a, 1966, 1968, 1969a): S = short-winged, D = dimorphic, and N = normal-winged.
[3] Total number of carabids collected using all methods.
[4] Found on island only.
[5] Found on mainland only.

tribution also seemed to apply, in general, to the data obtained in this study (Table 2).

The single *Pterostichus femoralis* collected had normal wings, although this dimorphic species usually is short-winged. Another dimorphic species, *Synuchus impunctatus* had unusually high numbers of specimens with long wings, 11.8% of the island and 25.0% of the mainland specimens (Lindroth,1966).

This study was the initial step in cataloging the insects of Valcour Island and the adjacent mainland area in Clinton County, New York. The results would be important in future studies designed to show how flora and fauna change with time, such as the study by Erwin (1981). More species will be added to faunal lists as collections are made as part of an ongoing effort at Plattsburgh State University College.

Acknowledgments

The authors are indebted to: Anthony Tyrell, Valcour Patrol Officer, for many assistances on Valcour Island; Jan Santa and Harry Leberthal for allowing collecting sites on their properties; Phillip Walker and Donald VanLeeuwen, SUNY College of Arts and Science at Plattsburgh, for their considerable assistance with plant identifications; Frank Kurczewski and Robert Mungari, SUNY College of Environmental Science and Forestry, for loaning specimens; and especially Ross T. Bell and Robert Davidson, University of Vermont, for use of Carabidae collections and laboratory facilities, as well as for their assistance in beetle identifications and interpretation of results. A Sigma Xi Grant-in-Aid of Research enabled the purchase of an ultraviolet insect trap.

Literature Cited

Barlow, C. A. 1970. Phenology and distribution of some *Pterostichus* (Coleoptera: Carabidae) of eastern Canada. J. N.Y. Entomol. Soc. 78: 215–236.

———. 1973. Phenology and distribution of *Carabus nemoralis* (Muller) (Coleoptera: Carabidae) in eastern Canada. Nat. Can. (Que.) 100: 361–369.

Barlow, C. A., J. E. Graham, and S. Adisoemarto. 1969. A numerical factor for the taxonomic separation of *Pterostichus pensylvanicus* and *P. adstrictus* (Coleoptera: Carabidae). Can. Entomol. 101: 1315–1319.

Briggs, J. B. 1960. A comparison of pitfall trapping and soil sampling in assessing populations of two species of ground beetles (Col.: Carabidae). East Mall. Res. Sta. (Annual Report), pp. 103–112.

Crissey, W. F. and R. W. Darrow. 1949. A study of predator control on Valcour Island. New York State Conservation Department. Division of Fish and Game, Research Series No. 1. Albany.

Darlington, P. J., Jr. 1936. Variation and atrophy of flying wings of some carabid beetles. Ann. Entomol. Soc. Am. 29: 136–179.

———. 1943. Carabidae of mountains and islands: Data on the evolution of isolated faunas, and on atrophy of wings. Ecol. Mono. 13: 39–61.

Erwin, T. L. 1981. Natural history of Plummers Island, Maryland. XXVI. The ground beetles of a temperate forest site (Coleoptera: Carabidae): An analysis of fauna in relation to size, habitat selection, vagility, seasonality, and extinction. Bull. Biol. Soc. Wash. 5: 104–224.

Goulet, H. 1974. Biology and relationships of *Pterostichus adstrictus* Eschscholtz and *Pterostichus pensylvanicus* Leconte (Coleoptera: Carabidae). Quaest. Entomol. 10: 3–33.

Klein, S. D. 1972. A comparison of the woodland small mammal populations of Valcour Island, Lake Champlain and a comparable mainland site. M.S. report. Plattsburgh State College, Plattsburgh, New York. 55 pp.

Larochelle, A. 1973. Wing dimorphism in *Carabus maeander* (Coleoptera: Carabidae). Pan-Pac. Entomol. 49: 126.

Leonard, M. D. 1928. A list of the insects of New York. Mem. Cornell Agric. Exp. Sta., No. 111, Ithaca, New York. 1121 pp.

Lindroth, C. H. 1957. The faunal connections between Europe and North America. Wiley, New York. 344 pp.

———. 1961. The ground beetles of Canada and Alaska. Part 2. Opus. Entomol. Suppl. 20: 1–200.

———. 1963a. The ground beetles of Canada and Alaska. Part 3. Opus. Entomol. Suppl. 24: 201–408.

———. 1963b. The fauna history of Newfoundland, illustrated by carabid beetles. Opus. Entomol. Suppl. 23 (Lund): 112 pp.

———. 1966. The ground beetles of Canada and Alaska. Part 4. Opus. Entomol. Suppl. 29: 409–648.

———. 1968. The ground beetles of Canada and Alaska. Part 5. Opus. Entomol. Suppl. 33: 649–944.

———. 1969a. The ground beetles of Canada and Alaska. Part 6. Opus. Entomol. Suppl. 34: 945–1192.

———. 1969b. The ground beetles of Canada and Alaska. Part 1. Opus. Entomol. Suppl. 35: I–XLVIII.

———. 1971. On the occurrence of a continental element in the groundbeetle fauna of eastern Canada. Can. Entomol. 103: 1455–1462.

Perrault, G. G. 1973. A taxonomic review of the eastern nearctic species complex *Pterostichus* (*Haplocoelus*) *adoxus* (Coleoptera: Carabidae). Quaest. Entomol. 9: 35–40.

Powell, J. E. 1977. First New York record for *Carabus maeander* Fischer (Coleoptera, Carabidae). Coleopt. Bull. 31: 148.